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OPTIMAL SPUTTERING CONDITIONS FOR HIGH-DENSITY MAGNETIC RECORDING MEDIA BY FTS

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ABSTRACT

Co-based alloy thin films ddeposited by fcing targets sputtering(FTS) were investigated for use in high-density magnetic recording media to determine how their magnetic properties are dependent on the sputtering conditions, and thus to find appropriate parameters that allow the sputtering and thin films to meet the specificiations for magnetic properties. FTS can discharge at lower working gas pressure than other sputtering methods such as dcmagnetron sputteing because the plasma is sufficiently confined by a magnetic field applied perpendicular to both of the target planes, which results in plasma-free substrates. Co-Cr-Ta films were deposited by FTS on glass and silicon substrates at substrate temperature between room temperature and 350℃, and at argon gas pressure between 0.1 and 10mTorr. The films were also deposited on polyimide tapes at substrate temperature of 130℃ and argon gas pressure of 1 mTorr. The effective advantages of Ta as an additional element were investigated, using the same films on the tapes. As a result of the experiment, it was found that better magnetic properties were obtained in the ranges of higher temperature and lower argon gas pressure with background pressure in thr range of 1.5×10^{-6} Torr. Ta addition at 2 to 4 atomic percent almost havled the Co-Cr grain sizes, indicating that Ta addition at an appropriate atomic percent is effective for improving the microstructure and characteristics of Co-Cr films.

INTRODUCTION

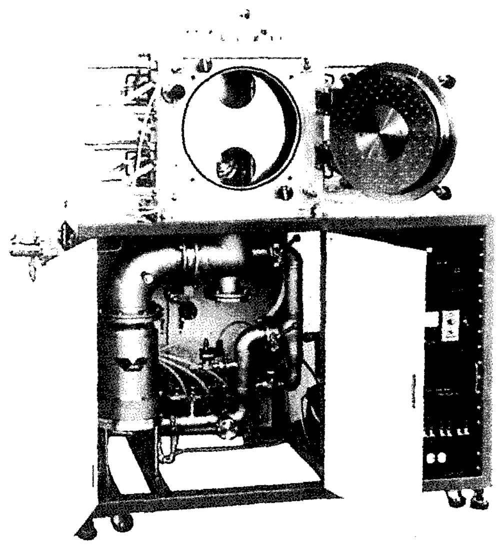
The areal density of hard disk dirves (HDDs) is increasing at a rate of around 60 % or more a year as a result of the implementation of magnetoresistive(MR) heads and advanced media with high coercivity, low noise, and other improved characteristics. In such high-density magnetic recording media, sputtering technologies are vital for obtaining appropriate magnetic properties, and various studies have been done on optimization of the sputtering conditions to meet the specifications for the media.[1-4] In this study, Co-based alloy thin films deposited by facing targets sputtering(FTS) were investigated for use in high-density magnetic recording media to determine how their magnetic properties are dependent on the sputtering conditions, and thus to find appropriate parameters that allow the sputtering and thin films to meet the specification for maggnetic properties.

In comparison with other sputtering methos., such as dc magnetron sputtering, FTS has several excellent characteristics such as plasma-damage free deposition, Ar gas pressure controllable as low as 0.1

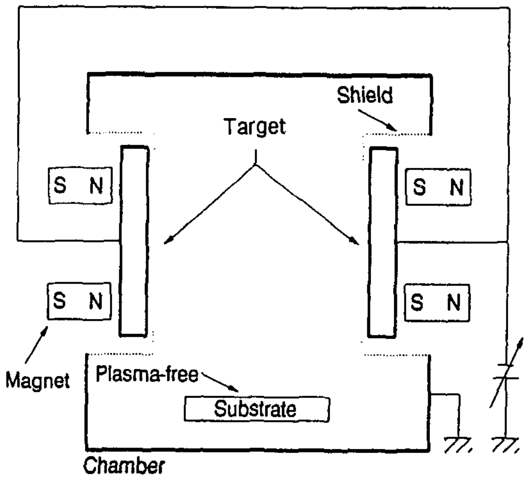
mTorr, and precise control of the deposited film's thichkness, i.e., definite linearity between te input power and deposition rate Determination of the sputtering conditions, namely, the substrate temperature, Ar gas pressure, background pressure, deposition rate, and input power, allowed the fabrication of highquality thin films for high-density magnetic recording media.

EXPERIMENTAL PROCEDURE

Figures 1 (a) and (b) show an overview and a schematic illustration of FTS, respectively. FTS can discharge at Ar gas pressure as low as 0.1 mTorr, because the plasma is sufficiently confined by a magnetic field applied perpendicular to both of the target planes. As a result, the films can be made without damagge due to plasma. Co-Cr-Ta/M(M:Cr, Cr-Ta, and Cr-Co)alloy thin films were deposited by FTS on 7059-glass substrates and 2.5-inch Si substartes. The substrate temperature(Ts) ranged from room temperature(R.T) to 350℃, while the argon gas pressure(PAr) ranged from 0.1 to 10 mTorr. A $Co_{83}Cr_{17-x}Ta_x$ film was also deposited on polyimide tapes at Ts of 130℃ and PAr of 1 mTorr. The effective advantages of Ta as an additional element were investigated, wuing the same films on the tapes. A vibrating sample magnetometer(VSM), X-raydiffraction (XRD), scanning electron spectroscopy (SEM), transmission electron microscopy(TEM), and read/write test system were used to charcterize the magnetic poperty.



(a) FTS overview



(b) FTS schematic illustration

Fig 1. Fcing targets sputting system.

RESULTS AND DISCUSSION

Dependence of the magnetic properties on the Substrate temperature

Figure 2 shows the dependence of coercivity Hc on Ts for Co-Cr-Ta/Cr, Co-Cr-Ta/Cr-Ta, and Co-Cr-Ta/Cr-Co films at PAr of 0.1 mTorr.

Figure 3 shows the dependence of Hc on Ts for Co-Cr, Co-Cr/Cr, and Co-Cr-Ta/Cr films at PAr of 2 mTorr. In the Co-Cr-Ta/Cr films, Hc at PAr of 0.1 mTorr was higher than at 2 mTorr, as expected.

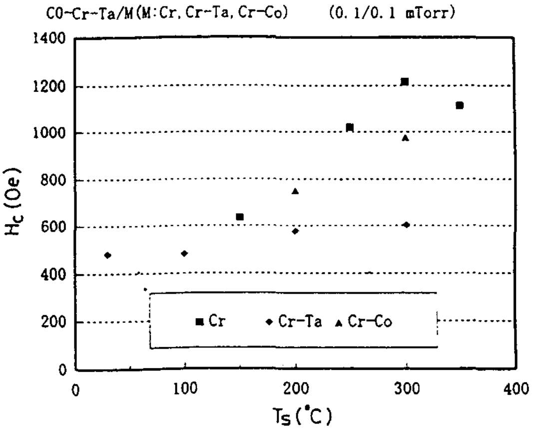


Fig. 2 Dependence of Hc on Ts for Co-Cr-Ta/Cr, Co-Cr-Ta/Cr-Ta, and Co-Cr-Ta/Cr-Co films at PAr of 0.1 mTorr.

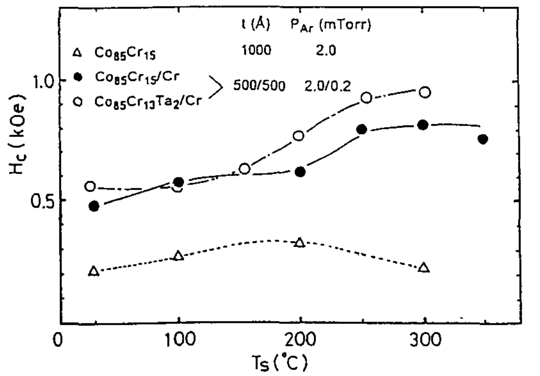


Fig. 3 Dependence of Hc on Ts for Co-Cr, Co-Cr /Cr, and Co-Cr-Ta/Cr films at PAr of 2 mTorr.

Dependence of the magnetic properties on the argon gas pressure

Figure 4 shows the dependence of the X-ray diffraction diagram on PAr for a Cr underlayer at Ts of 300℃. At Ar gas pressure below 9 mTorr, the peak grows from Cr(110) to Cr(200), indicating that the underlayer has better magnetic properties. Figure 5 shows the dependence of the crystallite sturcture on PAr and Ts for Co-Cr films measured by SEM.[1] Columnless and dense

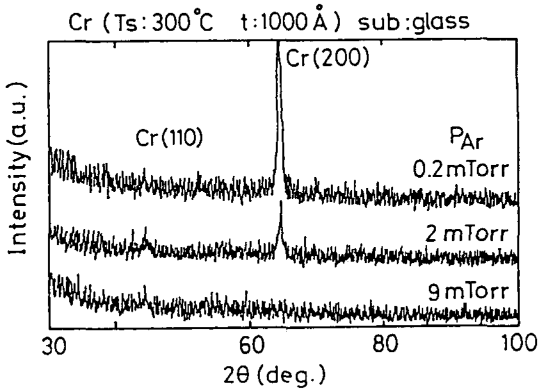


Fig. 4 Dependence of the X-ray diffraction diagram on PAr for a Cr underlayer.

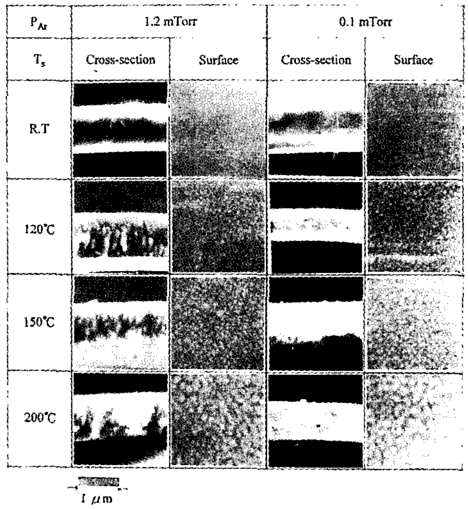


Fig. 5 Dependence of the crystallite structure on PAr andd Ts for Co-Cr films.

structure observed at PAr of 0.1 mTorr may indicate a grain separation, and result in media with low noise.

Dependence of the recording characteristics on the film thickness

Figure 6 shows the dependence of the frequency response on the magnetic film thickness for each disk at Ts of 100℃ and PAr of 0.2mTorr. The response with the 100-A film

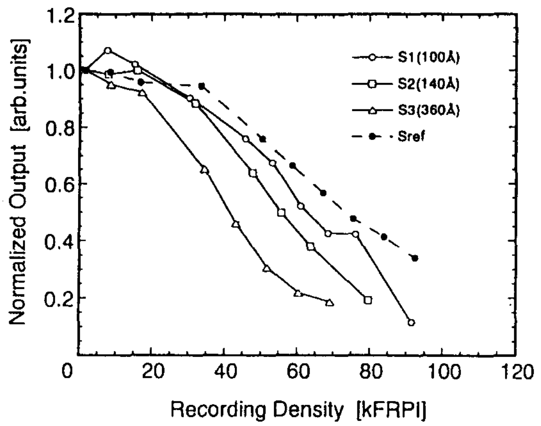


Fig. 6 Dependence of the frequency response on the film thickness for each disk at a linear velocity of 15m/sec.

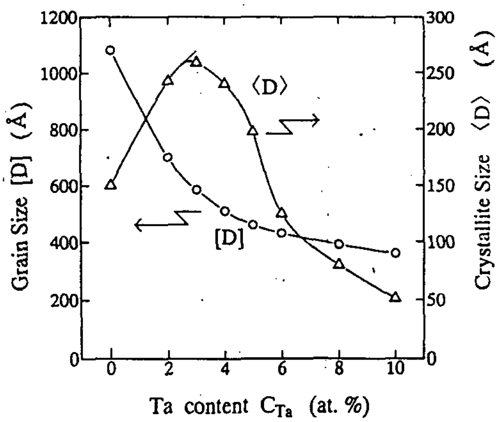


Fig. 7 Dependence of the grain and crystallite sizes on the Ta content for a Co83Cr17-xTax film.

was better than with thicker ones.[5] The film thickness can easily be controlled using the previously obtained deposition rate(A/min), which has defimite linearity between the rate and the input power. In this case, the deposition rates for the Cr and Co-Cr-Ta films were 240 and 100 A/min., respectively. The background pressure was below 1.5×10^{6} Torr.

Dependence of the grain and crystallite sizes on the Ta content for a Co-Cr-Ta film

Figure 7 shows the dependence of the grain and crystallite sizes on the Ta content for a Co 83Cr17-xTax film on a polyimide tape at Ts of 130℃ and PAr of 1 mTorr. Both grain and crystallite sizes were changeable by placing Ta slim sheets on a Co-Cr alloy plate target to control the Ta content at atomic percent. This is on of the most versatile characteristics of FTS. Table 1 lists the magnetic characteristics, such as Hc and the saturation magnetization Ms, in relation to the Ta content at atomic percent. It shows that Ta addition with 2 to 4 atomic percent yields the best magnetic characteristics.

Table 1 Dependence of the magnetic characteristics on the Ta content at atomic percent.

Ta Content C_{Ta}(at. %)	0	2~4	10
Grain Size [D] (Å)	1080	510~700	350
Crystallite Size[D] (Å)	150	240~255	50
Saturation Magnetization			
M_s (emu/cc)	700	370~500	220
Remanence Ratio			
$M_{r\perp}/M_{r//}$	1.0	3.3~4.4	3.2
Coercivity $H_{c\perp}$ (Oe)	1050	1600~2300	800
$M_{r//}$ (Oe)	300	150~200	130

CONCLUSIONS

The results obtained in this study were as follows :

1) Hc in the higher substrate temperature for Co-Cr-Ta/Cr films was higher than at Ts of 100℃ at PAr of 0.2mTorr with background pressure in the range of 1.5×10^{-6} Torr.

2) Hc at PAr of 0.1 mTorr for Co-Cr-Ta/Cr films was higher than at other high Ar gas pressure such as 0.2 and 2 mTorr.

3) The fequency response of the disk with the 100-A Co-Cr-Ta/Cr film was better

than that of disks with thicker films, and comparable with that of the reference disk with Co-Cr-Pt films.

4) SEM micrographs showed that the Co-Cr film had finer structure at Ts of 200℃ than at R.T., and finer structure at PAr of 0.1 mTorr than at 1.2 mTorr.

5) Ta addition at an appropriate atomic percnet was very effective for improving the nicrostructure and characteristics of Co-Cr films.

Consequently, the relationship between the sputtering conditions and magnetic properties was systematically clarified, using a facing targets sputtering system, and the excellent characteristics of the system were confirmed.

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